

## COMPONENT-MOUNTING METHOD AND COMPONENT-MOUNTING APPARATUS

## BACKGROUND OF THE INVENTION

The present invention relates to a method for mounting components such as electronic components, etc. on a circuit-formed substrate such as an electronic circuit board, and a component-mounting apparatus for carrying out the component-mounting method.

Fig. 6 shows an outline of a whole of a conventional component-mounting apparatus (1). In Fig. 6, the component-mounting apparatus (1) comprises, as main components, a component-feeding unit (2) composed of a cassette type component-feeding device for feeding components such as electronic components or the like; a tray-feeding unit (3) composed of a tray type component-feeding device; a mounding head (4) equipped with a plurality of nozzles for taking components out of both feeding units (2, 3) and mounting them on a circuit-formed substrate; an XY robot (5) for carrying the mounting head (4) to a predetermined position; a component-recognition camera (6) for recording and recognizing the condition of a component held by a nozzle of the mounting head (4); a circuit-formed substrate-securing device (7) for carrying the circuit-formed substrate to the component-mounting apparatus (1) and securing the same; and a control unit (9).

for controlling the operations of a whole of the component-mounting apparatus.

With reference to Fig. 6, a cassette type component-feeding device (8) having a reel onto which a lot of components are tape-like wound up is set on the component-feeding unit (2). A tray pallet type component-feeding device (10) on which a lot of components are arrayed is set on the tray-feeding unit (3). The mounting head (4) is equipped with nozzle heads (11) each having a nozzle (12) for sucking and taking a component (13) out of the component-feeding unit (2) or the tray-feeding unit (3). The angle of each nozzle (12) can be corrected by rotating on an axis Z by means of a rotation-controlling mechanism ( $\theta$  rotation). The X-Y robot (5) carries the mounting head (4) on a plane in X- and y-directions. The circuit-formed substrate-securing device (7) carries and secures the circuit-formed substrate (14) such as an electronic circuit substrate or the like. The mounting head (4) is equipped with a substrate-recognition camera (15) for recording and recognizing the condition of the circuit-formed substrate secured.

The component-mounting apparatus (1) thus constructed is operated as follows. The mounting head (4) moves just above a component (13) fed by the component-feeding unit (2) or the tray-feeding unit (3) and causes

each of the nozzles (12) to lower to contact and suck the component (13) and take it out of the component-feeding unit (2) or the tray-feeding unit (3), utilizing a negative pressure. Next, the mounting head (4), sucking and holding  
5 the component (13) at each of the nozzles (12), is carried by the X-Y robot (5) to a position facing to the component-recognition camera (6). The component-recognition camera (6) records and recognizes the component (13) sucked and held by each nozzle (12) of the mounting head (4) while the mounting head (4) is passing through the position facing to  
10 the component-recognition camera (6) at a predetermined speed. The inclination of the component (13) and a dislocation of the position thereof are measured based on the result of the above recognition.

15 The circuit-formed substrate (14) is carried by the circuit-formed substrate-securing device (7) and then regulated and secured at a predetermined position. When the mounting head (4) is moved to a position facing to the circuit-formed substrate (14), the substrate-recognition camera (15) provided on the mounting head (4) records and  
20 recognizes the circuit-formed substrate (14). The inclination or dislocation of the circuit-formed substrate (14) is measured based on the result of the recognition. The control unit (9) instructs, to each of the nozzle heads (11) mounted on the mounting head (4), a correction amount  
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of the position and inclination of the component (13) based on the position, inclination and dislocation of the circuit-formed substrate (14). Each of the nozzle heads (11) corrects the position and inclination of the component 5 (13) according to the instruction, and then mounts the component (13) at a predetermined position on the circuit-formed substrate (14).

Fig. 7A is a view through the substrate-recognition camera (15) provided on the mounting head (4), showing the condition of the circuit-formed substrate (14) regulated and secured. In this regard, one sheet of circuit-formed substrate (14) may compose a single electronic circuit substrate. However, in association with recent electronic devices with small sizes and light weight, downsizing of electronic circuit substrate is demanded, and thus, in many cases, a single circuit-formed substrate (14) is sectioned to provide a plurality of electronic circuit substrates as shown in Fig. 7A. In the example shown in Fig. 7A, the circuit-formed substrate (14) is sectioned for 20 9 individual substrates (16a) to (16i) which are arrayed in 3 rows and 3 columns. It may be sectioned for more individual substrates, for example, several tens of substrates. In the present specification, a whole of one sheet with an original size is referred to as the circuit-formed substrate (14), and any of specified and individual 25

substrates (16a) to (16i) is denoted by using an individual reference number or notation. Further, when not a specified individual substrate but the plurality of individual substrates provided from one circuit-formed substrate are generally referred to, such individual substrates are called individual substrates (16).

As shown in Fig. 7A, generally, a pair of reference marks (21) are provided at and around the corners on a diagonal line of the circuit-formed substrate (14). The substrate-recognition camera (15) recognizes both reference marks (21) of the circuit-formed substrate (14) being regulated and secured by the circuit-formed substrate-securing device (7), and the inclination of the circuit-formed substrate (14) and dislocation of the position thereof are measured based on the result of the recognition. The inclination of the circuit-formed substrate (14) and the dislocation of the position thereof are included in the correction amounts for the inclination of the component (13) and the dislocation of the position thereof when the component (13) is mounted.

On the other hand, generally, a pair of individual substrate marks (22) are provided at and around the corners of a diagonal line of each of the individual substrates (16). The component (13) itself becomes smaller in association with the downsizing of electronic devices as

mentioned above, and thus, the component-mounting density becomes higher. Therefore, it is required to accurately mount the components at predetermined positions without any interference with other components which have already been 5 mounted. The individual substrate marks (22) are used to make accurate positioning of components on each individual substrate (16).

In addition to the individual substrate marks (22), a position for indicating a bad mark (23) is provided 10 on the individual substrate (16). If some factors for failure such as incorrect mounting or non-mounting occur on a specified individual substrate (16) in any step of the process of mounting components on the circuit-formed substrate (14), a bad mark (23) is indicated on the relevant individual substrate (16). Generally, an operator 15 or an automatic machine puts a bad mark (23) by coloring it using a black ink or the like when finding a failure in the course of an intermediate inspection step or the like. This bad mark (23) is recognized by the substrate-recognition camera (15) based on the occupation ratio of 20 brightness (white and black are grasped based on their proportion by a binary value level). An individual substrate (16) attached with the bad mark (23) does not undergo a later component-mounting process so as to save 25 useless consumption of components and loss of tact time.

The arrows of the broken line shown in Fig. 7A indicate the passage along which the substrate-recognition camera (15) recognizes the bad marks (23). The recognition passage starts from the recognition of the bad mark (23) on the individual substrate (16a), followed by the bad marks (23) on other individual substrates (16b, 16c) on the same row, further followed by the bad mark (23) on the individual substrate (16d) in the next row, and the recognition is carried out in the same manner up to the final individual substrate (16i). In the example shown in Fig. 7A, bad marks (23) are put on the individual substrates (16a, 16c, 16e, 16h, 16i), respectively. Fig. 7B shows the passage of recognizing the individual substrate marks (22) after the recognition of the bad marks (23). Also, in this recognition passage, as indicated by the arrows of the broken lines, first, a pair of the individual substrate marks (22) of the individual substrate (16a) are recognized, followed by the individual substrate marks (22) of the individual substrates (16b) to (16i) in order.

Fig. 8 shows a flowchart of recognition operation by the substrate-recognition camera (15). In Fig. 8, the substrate-recognition camera (15) is moved to a position facing to the circuit-formed substrate (14) in accordance with the movement of the mounting head (14), and the

substrate-recognition camera (15) first recognizes the reference marks (21) at 2 positions of the circuit-formed substrate (14) at Step 51. In an actual recognition operation, the substrate-recognition camera (15) first takes up the image of the reference mark (21) at the first point into CCD. This image is inputted to the control unit (9) and stored therein. Next, the camera (15) recognizes the image of the reference mark (21) at the second point and takes it into CCD and inputs this image to the control unit (9) and stores therein. The inclination of the circuit-formed substrate (14) and dislocation of the position thereof are measured based on the result of the recognition of both reference marks (21) at the two points. Next, at Step 52, the camera (15) sequentially recognizes the bad marks (23) on the individual substrates (16) provided by sectioning the circuit-formed substrate (14) (total 9 points in the example shown in Fig. 7). As mentioned above, the data of the individual substrates (16) on which the bad marks (23) have been recognized are inputted to the control unit (9) so as not to undergo a later component-mounting step.

Next, at Step 53, the substrate-recognition camera (15) sequentially recognizes the paired individual substrate marks (22) on overall individual substrates (16) provided by sectioning the circuit-formed substrate (14)

(18 points in total in the example shown in Fig. 7). The results of the recognition of the individual substrate marks (22) are inputted to the control unit (9) so as to be reflected on correction amounts for an inclination and a 5 position of a component to be mounted in the later component-mounting step. After that, the component-mounting operation is carried out at Step 54, and the component (13) sucked by each of the nozzles is mounted on a predetermined position of each of the individual substrates (16).

10 However, the conventional component-mounting method as mentioned above has problems as follows. That is, in the operation of recognizing the individual substrates (16), first, the recognition of the bad marks (23) are 15 carried out (Step 52 of the flowchart shown in Fig. 8), followed by the recognition of the individual substrate marks (22) (Step 53 of the same flowchart), and therefore, a lot of recognition operations as a whole are required, and long time is required for such a lot of recognition 20 operations, which may adversely influence on a case of a circuit-formed substrate (14) which is sectioned into several tens of individual substrates. For example, in case of a circuit-formed substrate (14) sectioned into 77 individual substrates, as many as 231 times of recognition 25 operations in total are required for a single circuit-

formed substrate (14).

Next, the inclination of the circuit-formed substrate (14) and dislocation of the position thereof are recognized based on the results of the recognition of a pair of reference marks (21) on the circuit-formed substrate (14), and the results of this recognition are used in the calculation of the correction amounts for the inclination of the component (13) and the position thereof.

However, a recognition error may occur in the course of the operation of recognizing the individual substrate marks (22) on each of the individual substrates (16), depending on the degree of the inclination of the circuit-formed substrate (14), and thus, in some cases, the result of recognition of the reference marks (21) of the circuit-formed substrate is not effectively utilized. Fig. 9 shows one of such situations, in which, as indicated by the arrow of the broken line (25), a pair of reference marks (21) of the circuit-formed substrate (14) are first recognized by the substrate-recognition camera (15), and the inclination of the circuit-formed substrate (14) and dislocation of the position thereof are measured based on the results of the recognition. These results are used for calculation of correction amounts for the inclination of a component (13) to be mounted and dislocation of the position thereof.

In review of each of the individual substrates

(16), for example, the recognition of the individual substrate marks (22) of the individual substrates (16a, 16b) has no failure because the individual substrate marks (22) of the individual substrates (16a, 16b) are included in the visual field (31) of the substrate-recognition camera (15). In contrast, for example, in case of the individual substrate (16c), a component of the individual substrate mark (22) indicated by the circle is excluded from the visual field (31) of the camera (15) indicated by the square, which results in a recognition error. Such recognition errors similarly occur in case of the individual substrates (16f, 16g, 16h, 16i). If such a recognition error occurs, the following process may be optionally determined. However, correction amounts for the inclination and position of a component (13) can not be determined if such a recognition error is left unsolved. Therefore, the individual substrates (16) having such recognition errors have conventionally been judged as defectives. The individual substrates (16) judged as defectives are not subjected to the following component-mounting step. In other words, the individual substrates (16) which may be originally non-defectives are judged as defectives and are scrapped, depending on the inclination of the circuit-formed substrate (14).

To solve the problem induced by the above

recognition error, it is proposed to widen the visual field of the substrate-recognition camera (15). However, this solution has a problem in that, generally, the resolution of the camera degrades if the visual field of the camera is 5 widened, which leads to a further problem that the tact time becomes longer because the recognition of an individual substrate requires longer time. In addition, there is a danger of degrading the accuracy of recognition determined by the occupation rate of brightness mentioned above, because, by widening the visual field of the camera 10 (15), other factors may be included in the visual field of the camera (15) and because such factors may be recognized by mistake. At present, on the contrary, there is a tendency of narrowing the visual field of a recognition camera to improve the resolution of the camera and to thereby 15 reduce recognition time, so as to improve production efficiency. However, narrowing the visual field means more frequent occurrence of the foregoing recognition errors, which leads to a decrease in the yield of non-defectives. 20

Objects of the present invention are, therefore, to provide a component-mounting apparatus which is free from the above problems in the recognition operations of the circuit-formed substrate (14) of the conventional apparatus and which can carry out efficient recognition 25

operations to increase the yield of non-defectives and to thereby improve the productivity, and to provide a component-mounting method.

5      SUMMARY OF THE INVENTION

The present invention provides a method of mounting a component, which comprises the steps of recognizing a bad mark which is indicated on a circuit-formed substrate when each of at least one individual substrate provided by sectioning the circuit-formed substrate includes a defective individual substrate, and an individual substrate mark which is provided on the circuit-formed substrate so as to recognize the position and the inclination of each of at least one individual substrate as above; and mounting a component on the circuit-formed substrate, aiming at an individual substrate having no bad mark indicated; and the invention is characterized in that the bad mark is indicated on the individual substrate mark. This method is effective to improve the efficiency of the recognition operation by using the individual substrate mark also as the bad mark.

Another aspect of the present invention provides a method for mounting a component, which comprises the steps of recognizing the condition of a sucked component which is fed by a component-feeding device, sucked and

5 taken out; recognizing the condition of a secured circuit-formed substrate which is carried, regulated and secured; recognizing the position and the inclination of at least one individual substrate provided by sectioning the circuit-formed substrate; calculating correction amounts for the position and inclination of the component to be mounted, based on the result of the recognition of the component-sucking condition, the result of the recognition of the circuit-formed substrate-securing condition, and the result of the recognition of the position and inclination of the individual substrate; and making necessary correction on the component based on the result of the above calculation, and mounting the component at a predetermined position on the individual substrate; and the invention is characterized in that a mark which is provided on the individual substrate so as to recognize the position and inclination of the individual substrate is used also as a bad mark for discriminating a defective individual substrate. This method is effective to reduce the number of the recognition operations by the substrate-recognition camera, by using the individual substrate mark also as the bad mark.

20 Another aspect of the present invention is characterized in that the bad mark is indicated by coloring the individual substrate mark of an individual substrate

which is judged as a defective before mounting a component.

Another aspect of the present invention provides a method for mounting a component, which comprises the steps of recognizing the condition of a sucked component which is fed from a component-feeding unit, sucked and taken out; recognizing the condition of a secured circuit-formed substrate which is carried, regulated and secured; recognizing the position and inclination of at least one individual substrate provided by sectioning the circuit-formed substrate; calculating correction amounts for the position and inclination of the component to be mounted, based on the results of the recognition of the component-sucking condition, the circuit-formed substrate-securing condition, and the position and inclination of the individual substrate; and making necessary correction on the component based on the result of the above calculation, and mounting the component at a predetermined position on the individual substrate, and the invention is characterized in that a position at which a substrate-recognition camera should recognize the position and inclination of the individual substrate is controlled based on the result of the recognition of the circuit-formed substrate-securing condition. This method is effective to avoid occurrence of a recognition error by utilizing the inclination of the circuit-formed substrate and the

dislocation of the position thereof for the recognition operation of the individual substrate.

Another aspect of the present invention provides a method for mounting a component, which comprises the 5 steps of recognizing the condition of a sucked component which is fed from a component-feeding unit, sucked and taken out; recognizing the condition of a secured circuit-formed substrate which is carried, regulated and secured; recognizing the position and inclination of at least one 10 individual substrate provided by sectioning the circuit-formed substrate; calculating correction amounts for the position and inclination of the component to be mounted, based on the results of the recognition of the component-sucking condition, the circuit-formed substrate-securing 15 condition, and the position and inclination of the individual substrate; and making necessary correction on the component based on the result of the above calculation, and mounting the component at a predetermined position on the individual substrate; and the invention is 20 characterized in that, when a portion or a whole of a mark provided on the circuit-formed substrate so as to recognize the circuit-formed substrate-securing condition or a mark provided on the individual substrate so as to recognize the condition of the individual substrate is not included 25 within the visual field of a substrate-recognition camera

for recognizing these marks, the position of the mark is detected and the mark is again recognized. This method is effective to improve the yield of the non-defectives by detecting the position of the mark and again recognizing 5 the same mark, even if a recognition error occurs.

Another aspect of the present invention is characterized in that the position of the mark is detected based on a portion of the mark captured within the visual field of the substrate-recognition camera, and that the 10 mark is again recognized by moving the visual field of the substrate-recognition camera to the detected position.

Another aspect of the present invention is characterized in that the position of the mark is detected by enlarging the visual field of the substrate-recognition 15 camera, and that the mark is again recognized.

Another aspect of the present invention provides a component-mounting apparatus which comprises a component-feeding unit for feeding a component to be mounted; a mounting head for taking the component out of 20 the component-feeding unit and mounting it on a circuit-formed substrate; a component-recognition camera for recognizing the condition of the component held by the mounting head; an X-Y robot for carrying the mounting head to a predetermined position; a circuit-formed substrate-securing device for carrying and securing the circuit- 25

formed substrate; a substrate-recognition camera for recognizing the condition of the secured circuit-formed substrate; and a control unit for controlling the overall operations of the apparatus. With the above construction, 5 the substrate-recognition camera recognizes an individual substrate mark which is provided on each of at least one individual substrate provided by sectioning the circuit-formed substrate so as to recognize the position and inclination of the individual substrate; correction amounts for the position and inclination of the component to be mounted are calculated based on the result of the recognition of the individual substrate mark, the result of the recognition of the component-holding condition by the component-recognition camera, and the result of the 10 recognition of the circuit-formed substrate-securing condition by the substrate-recognition camera so as to make necessary correction on the component; and the mounting head is carried by the X-Y robot so as to mount the component at a predetermined position on the individual 15 substrate; and the invention is characterized in that a bad mark to be indicated when the circuit-formed substrate includes a defective individual substrate is put on an individual substrate mark of the defective individual substrate so that the substrate-recognition camera can 20 recognize the bad mark at the same time when recognizing 25

the individual substrate mark. The use of this apparatus is effective to improve the efficiency of the recognition operation by using the individual substrate mark also as the bad mark.

5 Another aspect of the present invention provides a component-mounting apparatus which comprises a component-feeding unit for feeding a component to be mounted; a mounting head for taking the component out of the component-feeding unit and mounting it on a circuit-formed substrate; a component-recognition camera for recognizing the condition of the component held by the mounting head; an X-Y robot for carrying the mounting head to a predetermined position; a circuit-formed substrate-securing device for carrying and securing the circuit-formed substrate; a substrate-recognition camera for recording and recognizing the condition of the secured circuit-formed substrate; and a control unit for controlling the overall operations of the apparatus. With the above construction, the substrate-recognition camera 10 recognizes an individual substrate mark which is provided on each of at least one individual substrate provided by sectioning the circuit-formed substrate so as to recognize the position and inclination of the individual substrate; correction amounts for the position and inclination of the 15 component to be mounted are calculated based on the result 20 25

of the recognition of the individual substrate mark, the result of the recognition of the component-holding condition by the component-recognition camera, and the result of the recognition of the circuit-formed substrate-securing condition by the substrate-recognition camera so as to make necessary correction on the component; and the mounting head is carried by the X-Y robot so as to mount the component at a predetermined position on the individual substrate; and the invention is characterized in that a position at which the substrate-recognition camera should recognize the individual substrate mark is controlled based on the result of the recognition of the circuit-formed substrate-securing condition. This apparatus makes it possible to avoid such a situation that the individual substrate mark is not recognized at all, as much as possible, by controlling the position of the substrate-recognition camera based on the result of the recognition of the position and inclination of the circuit-formed substrate.

Another aspect of the present invention provides a component-mounting apparatus which comprises a component-feeding unit for feeding a component to be mounted; a mounting head for taking the component out of the component-feeding unit and mounting it on a circuit-formed substrate; a component-recognition camera for recognizing

the condition of the component held by the mounting head; an X-Y robot for carrying the mounting head to a predetermined position; a circuit-formed substrate-securing device for carrying and securing the circuit-formed substrate; a substrate-recognition camera for recording and recognizing the condition of the secured circuit-formed substrate; and a control unit for controlling the overall operations of the apparatus. With the above construction, the substrate-recognition camera recognizes an individual substrate mark which is provided on each of at least one individual substrate provided by sectioning the circuit-formed substrate so as to recognize the position and inclination of the individual substrate; correction amounts for the position and inclination of the component to be mounted are calculated based on the result of the recognition of the individual substrate mark, the result of the recognition of the component-holding condition by the component-recognition camera, and the result of the recognition of the circuit-formed substrate-securing condition by the substrate-recognition camera so as to make necessary correction on the component; and the mounting head is carried by the X-Y robot so as to mount the component at a predetermined position on the individual substrate; and the invention is characterized in that, when a portion or a whole of a reference mark provided on the

circuit-formed substrate for recognizing the circuit-formed substrate-securing condition, or an individual substrate mark is not included within the visual field of the substrate-recognition camera, the substrate-recognition 5 camera detects the position of the mark and again recognizes the same mark.

Another aspect of the present invention is characterized in that the position of the mark is detected based on a portion of the mark captured within the visual field of the substrate-recognition camera, and that the mark is again recognized by moving the visual field of the substrate-recognition camera to the detected position. 10

Another aspect of the present invention is characterized in that the position of the mark is detected by enlarging the visual field of the substrate-recognition camera, and that the detected mark is again recognized. 15

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B are plan views of a circuit-formed substrate according to an embodiment of the present invention; 20

Fig. 2 is an operation flowchart of a process of recognition of the circuit-formed substrate shown in Fig. 1;

25 Fig. 3 is a plan view of a circuit-formed

substrate according to another embodiment of the present invention, illustrating a process of recognition thereof;

Figs. 4A and 4B are plan views of a circuit-formed substrate according to other embodiment of the present invention, illustrating a process of recognition thereof;

Fig. 5 is an operation flowchart of the process of recognition of the circuit-formed substrate shown in Fig. 4;

Fig. 6 is a perspective view of a conventional component-mounting apparatus;

Figs. 7A and 7B are plan views of a conventional circuit-formed substrate, illustrating an example of process of recognition thereof;

Fig. 8 is an operation flowchart of the process of recognition of the circuit-formed substrate shown in Fig. 7; and

Fig. 9 is a plan view of a conventional circuit-formed substrate, illustrating the problems in process of recognition of the circuit-formed substrate.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is described in detail by way of the following embodiments, which should not be construed as limiting the scope of the present invention in

any way.

A component-mounting apparatus and a component-mounting method according to the first embodiment of the present invention are described with reference to the 5 accompanying drawings.

Figs. 1A and 1B show a circuit-formed substrate (14) and recognition marks (21, 22, 23) according to the present embodiment. In this connection, the like components or components in the present embodiment and the following embodiments are denoted by the same reference numbers or notations. The components which are not included in the description of the present embodiment and the following embodiments are the same ones included in the conventional component-mounting apparatus and the conventional component-mounting method. 10 15

In Figs. 1A and 1B, a pair of reference marks (21) are provided on a diagonal line of the circuit-formed substrate (14), and individual substrate marks (22) are provided on the individual substrates (16a) to (16i), 20 respectively. This constitution is the same as that of the conventional apparatus.

The circuit-formed substrate (14) according to the present invention has no special position for a bad mark, and the individual substrate mark (22) is used also 25 as a position on which a bad mark should be put. In detail,

the individual substrate mark (22) is used to recognize the condition of each individual substrate (16) as in the conventional apparatus, and simultaneously used as the position on which an operator or a machine will color or 5 apply a bad mark when finding a defective factor such as incorrect mounting or non-mounting of a component on each individual substrate (16) in the course of the above recognition step.

Fig. 1A shows such a situation in which bad marks (23) are put on the individual substrates (16a, 16c, 16e, 16h, 16i) because some defective factors are found in them. The bad mark (23) may be put on either of two individual substrate marks (22) of each individual substrate (16). Based on the result of recognition of these bad marks (23) by the substrate-recognition camera (15), components (13) 10 are mounted on only the individual substrate (16b, 16d, 16f, 16g) on which the bad marks (23) are not applied, but not on the individual substrates (16) on which the bad marks (23) are put. The individual substrates (16) on which the components are mounted and the individual substrates (16) 15 on which the components are not mounted will be selected later into non-defectives and defectives, respectively.

Fig. 2 shows a flowchart for a recognition operation by the substrate-recognition camera (15). In Fig. 25 2, the substrate-recognition camera (15) moved to a

position facing to the circuit-formed substrate (14) in accordance with the movement of the mounting head (4), first, records and recognizes the images of a pair of reference marks (21) on the circuit-formed substrate (14)

5 at Step 1, and the inclination of the circuit-formed substrate (14) as a whole and dislocation of the position thereof are measured based on this recognition. Next, the substrate-recognition camera (15) sequentially recognizes two individual substrate marks (22) on each of the individual substrates (16) at Step 2. As mentioned above, bad marks (23) are previously put on the individual substrate marks (22) of the individual substrates (16) having some defective factors. Therefore, at Step 2, not only the conditions of the individual substrates (16) but also the bad marks (23) of the individual substrates (16) having some defective factors are concurrently recognized so as to distinguish the non-defectives from the defectives. Of the individual substrates (16) having no bad mark (23) found, the positions of the components (13) and the 20 correction amounts for their inclination are calculated based on the result of recognition of the individual substrate marks (22), and then, the components (13) are mounted on the predetermined positions of the individual substrates at Step 3.

25 In the above conventional apparatus, the

recognition operation of the bad marks (23) and the recognition operation of the individual substrate marks (22) are separately carried out as described above. In contrast, according to the present embodiment, it becomes 5 possible to save all the time required for the recognition operation for the bad marks (23), which leads to large time reduction. Further, a defective individual substrate (16) can be discriminated at once if a bad mark (23) is put on either of the pair of individual substrate marks (22) which has been found earlier in one individual substrate (16), and the recognition operation for the other individual substrate mark (22) becomes unnecessary, which leads to a further reduction of tact time. In this regard, although the present embodiment is described as using one circuit-formed substrate which are sectioned for a plurality of 10 individual substrates (16), it is also possible to apply the present embodiment to one circuit-formed substrate provided for a single individual substrate. In this case, the reference marks (21) of the circuit-formed substrate 15 can be used as individual substrate marks (22). 20

Next, a component-mounting apparatus and a component-mounting method according to the second embodiment of the present invention are described with 25 reference to the accompanying drawings. As has been

already described with reference to Fig. 9 for the conventional apparatus, when the inclination of the circuit-formed substrate (14) and dislocation of the position thereof are recognized by the recognition 5 operation for the reference marks (21) of the circuit-formed substrate (14), the results of this recognition are reflected on only the correction of the inclination of the component (13) to be mounted and the position of the component (13). If the inclination of the circuit-formed 10 substrate (14) is large, the individual substrate marks (22) are not included within the visual field (31) of the substrate-recognition camera (15), which disadvantageously becomes a factor for a recognition error. Fig. 3 15 illustrates a recognition operation for the circuit-formed substrate (14) according to the present embodiment. In Fig. 3, the circuit-formed substrate (14) is supposed to incline an angle of  $\alpha$  relative to a normal condition shown in Figure as a result of the recognition of the reference marks (21) of the circuit-formed substrate (14) by the 20 substrate-recognition camera (15). In the present embodiment, the recognition result reflects on not only correction amounts for the inclination and position of the component (13) but also a recognition operation for bad marks (23) by the substrate-recognition camera (15) (see 25 Step 52 in Fig. 8) and a recognition operation for

individual substrate marks (22) by the substrate-recognition camera (15) (see Step 53 in Fig. 8) at the next step.

Thus, as indicated by the broken line (28) in Fig. 5 3, when recognizing the individual substrate marks (22), the substrate-recognition camera (15) moves to a position which is predetermined by reflecting the above inclination  $\alpha$  of the circuit-formed substrate (14), so as to carry out a recognition operation for each of the individual substrates (16). Therefore, the individual substrate marks (22) can be easily captured within the visual field (31) of the substrate-recognition camera (15). This avoids a recognition error relative to the individual substrate mark (22), and further a misjudge of a non-defective individual substrate as a defective based on such a recognition error. Thus, a component is mounted on a predetermined position of each individual substrate (16). That is, reflecting the recognition result of the circuit-formed substrate (14) on the recognition operations for the bad marks (23) and also 10 the individual substrate marks (22) by the substrate-recognition camera (15) leads to an improvement on the yield of non-defectives and also an increase in the production efficiency of the component-mounting process. 15

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Since it becomes easy to avoid a recognition error by the substrate-recognition camera (15), it becomes 25

possible to further narrow the visual field of the substrate-recognition camera (15), which provides a possibility to reduce the tact time for a recognition operation in association with an improvement on the 5 resolution. Since a lot of recognition operations are required for bad marks (23) and individual substrate marks (22) of one circuit-formed substrate (14), further reduction of the tact time by narrowing the visual field of the camera is particularly effective to a circuit-formed substrate which is sectioned for far more individual substrates.

Although Fig. 3 shows the conventional circuit-formed substrate (14) which separately provides the bad marks (23) on the respective individual substrates (16), the bad marks (23) may be eliminated and the individual substrate marks (22) may be used also as the bad marks (23) as described in the component of the first embodiment.

Next, a component-mounting apparatus and a 20 component-mounting method according to the third embodiment of the present invention are described with reference to the accompanying drawings. In Fig. 4A, the visual field (31) of the substrate-recognition camera (15) is formed as a substantially right square around the center (32) of the 25 camera. When the reference mark (21) of the circuit-formed

substrate (14) is recognized by such a substrate-recognition camera (15), a whole of the reference mark (21) is generally required to be included within the visual field (31). If a component of the reference mark (21) (the 5 hatched portion (33)) is excluded from the visual field (31) as shown in Fig. 4A, the conventional component-mounting apparatus would judge it as a recognition error. Since it is impossible to calculate a correction amount for the position of the circuit-formed substrate (14) so as to carry out the following component-mounting, such a circuit-formed substrate is scrapped as a defective. Also, the 10 individual substrate (16) is scrapped in the same manner as a defective if a recognition error is found in the individual substrate mark (22).

15 On the other hand, where even a component of the reference mark (21) of the circuit-formed substrate (14) is included within the visual field (31) in the present embodiment, the position of the reference mark (21) is detected based on such a component of the reference mark 20 (21). In an example shown in Fig. 4A, the length "a" of one side of the reference mark (21) is known from the shape of the reference mark (21) known in advance, and it is possible to measure the length "b" of a component of the side captured within the visual field (31), based on which 25 the portion (the hatched portion (33)) of the reference

mark (21) excluded from the visual field (31) of the substrate-recognition camera (15) can be estimated. Therefore, it is also possible to estimate the position of the center (34) of the reference mark (21), so that it 5 becomes possible to calculate "x" and "y" as amounts of dislocation between this center (34) and the center (32) of the substrate-recognition camera (15).

In the present embodiment, as described above, 10 recognition of only a component of the reference mark (21) in the first recognition operation is not judged as a recognition error, and the position of the reference mark (21) is detected and the amounts "x" and "y" of dislocation of the center position are calculated. Next, the positioning of the substrate-recognition camera (15) is again done by taking into account the above calculated 15 dislocation amounts, and then, the second recognition operation is carried out. By doing so, the reference mark (21) is set around the center (32) of the visual field (31) as shown in Fig. 4B. Widening the visual field of the 20 substrate-recognition camera (15) to reduce the number of recognition errors leads to an increase in tact time required for all the recognition operations, resulting in a lower production efficiency. In the above method according to the present embodiment, it is sufficient to carry out 25 the second recognition operation, aiming at only the

reference mark (21) which would be conventionally judged as a recognition error. Thus, the above mentioned time loss caused by widening the visual field can be avoided, and the efficiency of the recognition operation is improved.

5           Although the square marks are employed in the drawings, it is easy to detect the center position of a mark to be recognized if such a mark has a shape of circle, triangle or the like, provided that the shape of this mark is previously known. Further, such detection of a mark can be applied to not only the reference mark (21) but also the individual substrate marks (22).

Fig. 5 shows the flowchart of the recognition operation by the substrate-recognition camera (15) according to the present embodiment. In Fig. 5, the substrate-recognition camera (15) moved to a position facing to the circuit-formed substrate (14) in accordance with the movement of the mounting head (4), first, recognizes the reference mark (21) of the circuit-formed substrate (14) at Step 11. If normally recognizing the reference mark (21) at Step 11, the substrate-recognition camera (15) sequentially recognizes the individual substrate marks (22) of all the individual substrates (16) on a plurality of sections of the circuit-formed substrate (14) at Step 12. In this recognition operation, the conditions of the individual substrates (16) and

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discrimination of the non-defectives from the defectives thereof are recognized depending on the presence or absence of bad marks (23) described in the component of the first embodiment. If the individual substrate mark (22) can be 5 normally recognized at Step 12, the correction amounts for the inclination of the component (13) and the position thereof are calculated based on the recognition results at Steps 11 and 12. Then, the component (13) is mounted on a predetermined position at Step 13.

10 If only a component of the reference mark (21) of the circuit-formed substrate (14) is recognized at Step 11, the program goes to Step 16, at which the position of the reference mark (21) is detected and the dislocation amount from the substrate-recognition camera (15) is calculated. 15 The substrate-recognition camera (15) moves based on the result of the calculation and carries out the second recognition operation relative to the reference mark (21) at Step 17. If a normal recognition operation is done at Step 17, the program goes to Step 12, and then, the component-mounting operation is carried out following the 20 above-mentioned flowchart.

25 If only a component of the individual substrate mark (22) is recognized at Step 12, the program goes to Step 18, at which the position of the individual substrate mark (22) is detected and the amount of dislocation from

the substrate-recognition camera (15) is calculated. The substrate-recognition camera (15) moves based on the result of the above calculation and carries out the second recognition operation relative to the individual substrate mark (22) at Step 19. When a normal recognition operation is carried out at this step, necessary correction for the component is done in the same manner as above, and the component-mounting operation is carried out at Step 13.

10 The operation flows indicated by the broken lines on the left side of Fig. 5 optionally can be provided. In other words, even if the reference mark (21) of the circuit-formed substrate (14) can not be recognized at all, it is supposed that the reference mark (21) should be in the vicinity of the visual field (31). Therefore, the visual field (31) of the substrate-recognition camera (15) is enlarged at Step 21 and the second recognition operation is carried out at Step 22. The time required for the recognition operation becomes longer in case where the visual field is widened. However, this is done on only a 15 circuit-formed substrate (14) in an abnormal condition under which the reference mark (21) can not be recognized at all. It is considered that, in some cases, it is more economically advantageous to again recognize such a circuit-formed substrate (14) by enlarging the visual field 20 of the camera rather than to scrap this circuit-formed 25

substrate (14) as a defective. If the reference mark (21) can be normally recognized by widening the visual field, the program returns to Step 12 and proceeds according to the normal operation flow. In this regard, in case where 5 only a component of the reference mark (21) is recognized even after the visual field is enlarged at Step 21, the operations described at Steps 16 and 17 may be again repeated, that is, the position of the mark is detected, and the reference mark is again recognized.

Similarly, in case where the individual substrate mark (22) can not be recognized at all in the recognition operation for the individual substrate mark (22) at Step 12, the program optionally may proceed to Step 23 to enlarge the visual field of the substrate-recognition camera (15) and again recognize the individual substrate mark (22) at Step 27. However, in this case, it is only one individual substrate (16) that can be remedied, and thus, the cost-effectiveness is relatively small as compared with the case where a whole of the circuit-formed substrate (14) are remedied at Step 21. When the individual substrates (22) have been recognized by the operation of the above re-recognition, the program proceeds to Step 13 to correct the inclination and position of the component (13) and mount it at a predetermined position.

in Fig. 5 is made for concurrent recognition of the individual substrate mark (22) and the bad mark (23) at Step 12. However, the individual substrate mark (22) and the bad mark (23) may be separately recognized as in the 5 conventional apparatus. Otherwise, it is desirable that, as in the second embodiment, after the recognition of the reference mark (21) at Step 11, the result of the recognition is utilized to correct the position of the substrate-recognition camera (15) in the course of 10 recognizing the individual substrate mark (22) at Step 12.

15 The foregoing descriptions have been made for the component-mounting methods and the component-mounting apparatuses according to the embodiments of the present invention in which a plurality of individual substrates are provided from one circuit-formed substrate. However, as referred to in the component of the first embodiment, the scope of the present invention is not limited to the above 20 circuit-formed substrate from which the plurality of individual substrates are provided. The present invention also can be applied to a single substrate provided from one circuit-formed substrate as well.

25 According to the component-mounting apparatuses and the component-mounting methods of the present invention,

it is possible to decrease the number of the recognition steps for the marks of a single or a plurality of individual substrate(s) provided from a circuit-formed substrate, and thus to save the tact time required for the 5 recognition process and to improve the production efficiency.

Further, according to the component-mounting apparatuses and the component-mounting methods of the present invention, it is possible to reduce the rate of causing recognition errors, and also it is possible to remedy a circuit-formed substrate or individual substrates which are conventionally scrapped as defectives and to provide them as non-defectives. Therefore, the yield of non-defectives obtained in the course of mounting components can be improved. 10 15

Further, according to the component-mounting apparatuses and the component-mounting methods of the present invention, since it is possible to reduce the rate of causing recognition errors, the resolution of the substrate-recognition camera can be improved by narrowing the visual field of the camera, so that the tact time required for the recognition process can be reduced, which leads to higher production efficiency. 20

It should be noted that this application is based 25 upon the Japanese Patent Application No. 2000-374428, which

is entirely incorporated herein by reference.